Prairie Research Institute
Illinois Natural History Survey

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Research and Analysis of Fisheries in Illinois

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RESEARCH AND ANALYSIS OF FISHERIES IN ILLINOIS

F-69-R (25)

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August 2012

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EXECUTIVE SUMMARY

Fisheries managers are charged with understanding the interaction between sport fish populations and anglers to inform resource management decisions that support and promote healthy fisheries. Fundamental to this mission is easy access to long-term fisheries data, analytical tools and metrics that offer insight into the quality of a fishery and an understanding of the factors that influence fish population dynamics. Equally important is the need to communicate this scientific knowledge and promote angling opportunities to the public.

Project F-69-R has three overall goals: (1) conduct a wide variety of research studies that elucidate patterns of variation in sport fish populations and the mechanisms that drive those patterns, (2) communicate research findings and basic assessments of sport fish populations to the angling public, and (3) organize, manage, analyze and deliver sport fisheries data to researchers, sport fish managers, and the angling public. Basic and applied research studies, public outreach efforts, and data management activities all work in concert to create a better understanding of the restoration and conservation needs of sport fish populations in Illinois.

Research studies completed in Segment 25 were executed under Job 101.1, Job 101.3, Job 101.4, and Job 101.6. Summarized below, these studies were focused on four areas of sport fish restoration and management. First, development of a Fishing Quality Index (FQI) for sport fish was initiated under Job 101.1 utilizing 20 years of existing creel survey data (collected during previous segments of Project F-69-R) and fisheries independent samples of sport fish populations throughout Illinois. Second, several studies under Job 101.3 explored factors that impact recruitment processes in black bass (*Micropterus* spp.), including the impacts of reproductive success on smallmouth bass recruitment (see p. 12) and the impact of brood loss on nest abandonment decisions by largemouth bass (*M. salmoides salmoides*; see p. 17). Third, several studies examined the physiological and stress-related responses by native sport fish (*Lepomis macrochirus* and *M. salmoides salmoides*) to environmental stressors, such as low oxygen and high carbon dioxide levels. Fourth, field sampling in support of the next iteration of "Fishes of Champaign County" was initiated under Job 101.6.

Outreach activities under Job 101.5 primarily consist of the maintenance of the website www.ifishillinois.org. The website is a heavily visited, popular resource for anglers seeking information about sport fishing opportunities in Illinois. The site provides basic information about access, as well as science-based assessments about the quality of sport fishing in Illinois waters. Through Job 101.5 we are able to communicate the results of sport fish research and analysis, delivering state-of-the-art information to researchers, managers, and the angling public. Social media was added as a complement to the website and will continue to be utilized to promote and share information about sport fishing opportunities throughout Illinois. Additionally, collaborative efforts between project personnel and IDNR Division of Fisheries created materials for public fishing shows throughout the state. The website, social media, and public outreach activities are essential to sharing public data and information about sport fish populations and management in Illinois.

Sport fish data sets are the building blocks that support research studies and outreach activities within Project F-69-R, making the collaborative collection, organization, analysis, and dissemination of sport fish information a critical component of the overall goals of this project. Through collaborations with the Illinois Department of Natural Resources, Project F-69-R provides additional resources needed to efficiently collect and manage data that reflects that status and trends in sport fish populations in Illinois, and organizes that information in such a way that the needs of all data users can be more efficiently met.

The importance and value of Project F-69-R lies in the ability to be responsive to emerging sport fish management issues through research studies and long-term sport fish data sets, followed by compelling and salient communications of those findings to the angling public. The Executive Summary provides a brief overview of the accomplishments of each job within the project, followed by a more detailed reporting of the specific procedures, findings and recommendations for future activities under this project.

JOB 101.1 SPORT FISH POPULATION AND SPORT FISHING METRIC

Using long-term sport fisheries data, project staff has developed and is continuing to test a Fishing Quality Index (FQI) for largemouth bass. Fisheries-dependent data were assembled using creel survey data from 1990 – 2009 and collected in previous segments of Project F-69-R. Satisfaction scores of anglers who were expressly targeting largemouth bass were used as the response variable in the FQI scoring model. IDNR personnel gathered fisheries independent data during fall boat electroshocking surveys, and common population metrics (PSD, average TL, CPUE, condition, and various RSDs) were used to create a scoring model based on the metrics that were most highly correlated with angler success ratings. FQI scoring models continue to be developed for additional sport fish species.

JOB 101.2 ENHANCED FIELD SAMPLING OF SPORT FISH POPULATIONS

Project F-69-R has awarded several undergraduate students majoring in fisheries management (or related fields) the opportunity to participate in enhanced field sampling activities during the summer months. Interns worked directly with IDNR Division of Fisheries to conduct sampling of stream fish assemblages in over 100 sampling sites within the Vermilion, Lower Cache, Embarass, Skillet Fork, Wabash, Sangamon, and Iroquois River Basins and are currently sampling the Hennepin Canal, Green River, Pecatonica River, and the Lower Kaskaskia River basins in 2012. This collaboration results in an increased number of sites sampled and promotes the sharing of data in support of research studies under this and other Federal Aid projects.

JOB 101.3 DETERMINE FACTORS AFFECTING FISHING QUALITY

In the current segment, project personnel conducted field studies examining processes that determine reproductive success in largemouth bass with the goal of gaining a better understanding how angling during the reproductive period may influence recruitment dynamics and ultimately fishing quality.

These experiments showed that there is a direct, positive relationship between the number of reproductively successful nests within a population of smallmouth bass and recruitment to age 1+ the following season (Experiment 3.3). Preliminary results of Experiment 3.4 indicate a similar relationship between reproductive success and recruit abundance in largemouth bass with further analyses on this 20-year data set currently in progress. The results of Experiment 3.6 demonstrate that experimental brood depredation induces premature nest abandonment by parental largemouth bass. Together these studies show how angling is an important component of recruitment dynamics in black bass, and how life history characteristics are critical factors in understanding variability in sport fish abundance and ultimately fishing quality.

JOB 101.4 COORDINATION WITH ONGOING FISHERIES RESEARCH PROJECTS

Project personnel continue to provide support for a various ongoing fisheries research projects by providing information about sport fish populations from sport fish data sets, demonstrating the importance of collaborative collection, organization, analysis, and dissemination of sport fish information.

In FY2011, CAWFS-74, along with support from F-69-R project personnel, continued projects to develop novel molecular stress indices (i.e., development of stress biomarkers) using largemouth bass and bluegill (Experiment 4.2). Results from this study represent a significant improvement in our ability to quantify stress and disturbance in sport fishes, enabling the use of techniques to identify healthy vs. "stressed" populations of largemouth bass and bluegill, as well as in other species.

In March of 2011, an estimated 300,000 Chinook salmon were marked at Jake Wolf Fish Hatchery (IDNR) as part of a lake-wide, inter-agency collaboration spearheaded by the U.S. Fish and Wildlife Service, and also involving Michigan DNR, Indiana DNR, and Wisconsin DNR (Experiment 4.6). Project personnel have collected tag data from anglers who caught tagged Chinook salmon in Illinois waters. Of the 483 Chinook captured, 64 (13.3%) contained coded wire tags. Most (49%) Chinook salmon that entered the Lake Michigan fishery came from Wisconsin waters, with 31% coming from Michigan, 11% from Illinois, and 6% from Lake Huron; 3% of tags were lost. The number of Chinook salmon migrating from Lake Huron was an unexpected finding and is something all agencies will need to continue monitoring if reducing the predator burden on alewife (Chinook salmon's main forage fish) populations continues to be a management priority.

During Segment 25, project personnel initiated collaboration with the Landscape Conservation Cooperative project "Predicting Climate Change Effects on Riverine Aquatic Insects Using Museum Data and Niche Modeling." We used species occurrence records for more than 100 stonefly species (*Insecta*: *Plecoptera*), distributed across the five-state Upper Midwestern study region (OH, IL, IN, MI, WI), to build species distribution models to summarize patterns of richness and diversity at a series of spatial scales. All suites of models predict similar patterns of species richness. Most notably, there are "hotspots" of higher maximum species richness along much of the southern margin of the study area, just north of the Ohio River, but also in the northeastern portions of Wisconsin and the Upper Peninsula of Michigan (Figure 7). Future work

will provide assessments of the change in climates predicted by regionally downscaled models for the five-state Upper Midwest region and will be used to predict changes in the availability and quality of fish habitat for fishes.

Access to fisheries data sets and the efficient and coordinated management of those data sets are critical to the successful completion of all aspects of Project F-69-R. Project personnel have begun developing options for modifying how sport fish information is managed to efficiently integrate multiple data sources, include sufficient geospatial data, and broaden the scope of use of the information to support research and management activities. Efficiently integrating sport fish data sets is a difficult endeavor that requires the continued attention of F-69-R project personnel and a strong collaborative partnership with IDNR Division of Fisheries.

JOB 101.5 SUPPORT AND ENHANCE WEB INTERFACE

Project personnel continue to maintain the website www.ifishillinois.org as the primary method for providing online information about sport fishing opportunities to the public. The website provides information about Illinois sport fish, including weekly fishing reports, findings on long-term analyses of sport fisheries data, trends in fishing quality, and the promotion of Illinois as a fishing destination. An average of over 680 people visited www.ifishillinois.org each day to read information about fishing opportunities in Illinois. Significant additions to the website included guidelines and information in a new "Conservation Angling" section that provides introductory materials encompassing all types of angling, including: Introduction to Conservation Angling, Code of Angling Ethics, Conservation Practices for Anglers, Catch-and-Release Guidelines, and Science of Recreational Angling. To further promote fishing opportunities to anglers in Illinois, project personnel have employed social media tools (i.e., Facebook) to develop online communities interesting in Illinois fishing.

JOB 101.6 FISHES OF CHAMPAIGN COUNTY

Building on the efforts of Forbes and Richardson (1908), Thompson and Hunt (1930), Larimore and Smith (1963), and Larimore and Bayley (1996), field sampling for the next iteration of "The Fishes of Champaign County" was initiated in Segment 25. During this project segment, 38 sites yielded 42 fish species in the Embarras River and Kaskaskia River basins.

Using an electronic plat map of Champaign County and a sample site map, landowners were identified for a mail survey to assess landowner's perceptions and attitudes regarding fisheries resources in their local streams. The survey had a very high 52% return rate, and preliminary results show that only 22% of responding landowners are recreational anglers and the majority of them fish public lakes and private ponds. Thirty-six of 98 of the responders (37%) allow fishing on their Champaign County stream. We also asked about the landowner's participation and knowledge of certain government programs and found that 51% participate in CRP/CREP, while only 12% have heard of the Illinois Recreational Access Program (IRAP).

JOB 101.1 SPORT FISH POPULATION AND SPORT FISHING METRIC

OBJECTIVES

The following components constitute the overall objectives for Job 101.1:

- Develop and test a wadeable and non-wadeable Fishing Quality Index (FQI) for common Illinois sport fish species using fisheries data collected through standardized field sampling and creel surveys.

PROCEDURES

Using long-term sport fisheries data, project staff has initiated the development and testing of a Fishing Quality Index (FQI) for individual species of sport fish, as well as on sport fish assemblages for individual lakes, rivers and streams across Illinois. Historical creel survey data from 1990 – 2009 will continue to be used to parameterize the fisheries-dependent components of the FQI metric. As development and testing of the FQI continues, standardized sampling data of Illinois lakes, rivers and streams will be used to parameterize the fisheries-independent components of the FQI metric for both wadeable and non-wadeable systems. Ultimately, an annual wadeable and non-wadeable FQI will be calculated for several sport fish species on individual bodies of water (lakes, rivers, and streams) across Illinois and could be used in concert with traditional sport fisheries management metrics (e.g., proportional stock density, PSD) to more fully describe the interaction between population structure and quality of angling experience.

Project personnel started development of an FQI scoring model for largemouth bass, as it is one of the most popular sport fish species in Illinois, is common in almost all lakes, and provides a large amount of usable data for testing. To create a tool that will be useful and valuable to fisheries managers, project staff developed an FQI scoring model that uses metrics obtained through fisheries independent sampling efforts by IDNR Division of Fisheries to predict the quality of fishing based an angler's perception of angling success in a certain water body. To achieve this goal, historical creel survey data was selected where electrofishing surveys had been conducted the fall prior to the creel survey, thus combining both fisheries dependent and fisheries independent data into the FQI scoring model. Anglers interviewed during creel surveys in Illinois were asked to rank their angling experience on a scale from 1 to 10, with 10 being the highest. Satisfaction scores of anglers who were expressly targeting largemouth bass were used as the response variable in the FQI scoring model. IDNR personnel gathered fisheries independent data during fall collections with a boat electroshocker, and common population metrics (PSD, average TL, CPUE, Condition, and various RSDs) were used to create a scoring model based on the metrics that were most highly correlated with angler success ratings.

FINDINGS

A total of 33 lakes were found to have a fall electrofishing survey the year before a creel survey. No creel surveys conducted before 1999 were used because these surveys did not ask the anglers to give a success rating. The best model for predicting largemouth bass angling success used CPUE, average TL and PSD based on electrofishing samples ($p = 0.011$, adj. $R^2 = 0.24$). FQI scores were then compared to the original Average Angler Success rate from that lake. The resulting regression was significant ($p = 0.001$; Figure 1). Results from this model produced raw FQI scores ranging from 3.26 to 4.96, and those raw FQI scores were applied to an interim scoring system to assign an FQI grade to each of the 33 lakes used to develop the model (Table 1).

FQI Grading Criteria		
FQI Score Range	**FQI Grade**	**Number of study lakes**
> 4.5	A	4
4.0-4.5	B	16
3.5-4.0	C	9
3-3.5	D	4
< 3	F	0

Table 1. Grading criteria for largemouth bass FQI scores and the number of study lakes receiving each grade.

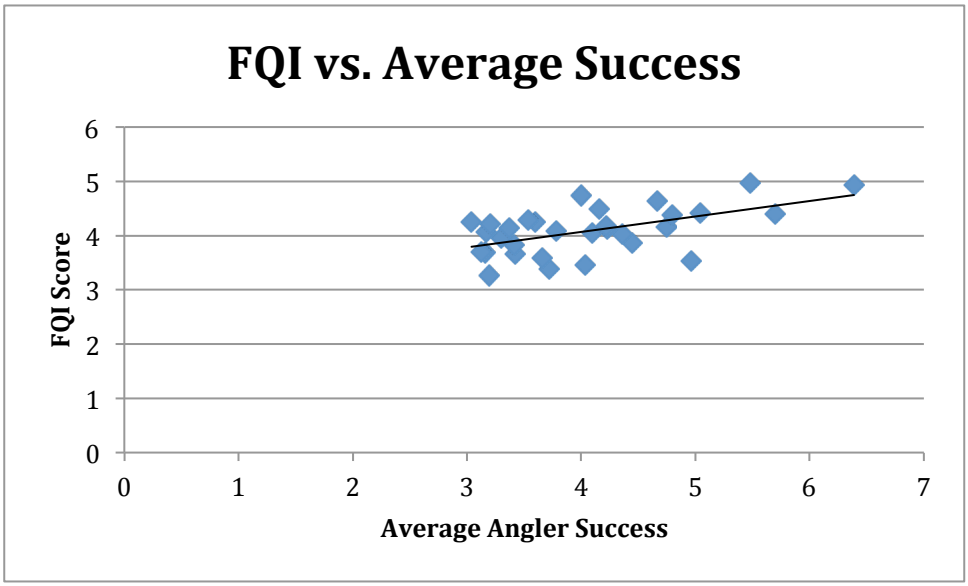

Figure 1: Scatter plot comparing largemouth bass average angler success to FQI score for 33 lakes used to develop the scoring system.

RECOMMENDATIONS

The FQI scoring system developed thus far is still a work in progress, but does set the stage for further testing. First, project personnel should assess the relative contribution of fisheries dependent metrics (e.g., angling CPUE, average size of catch) to overall angler satisfaction, so

that creel survey data that lacks angler satisfaction responses can be incorporated into testing of the scoring model. Second, a scoring scheme for each component of the FQI should be developed and tested now that fisheries independent metrics that correlate with angler satisfaction have been identified. Weighting of component scores should follow the overall scoring model developed thus far. Third, novel combinations of fall electrofishing and creel survey data the following year should be used to validate the scoring system. Lastly, project personnel should explore additional factors that may have an effect on angling success. Some of these factors may include lake level, number of rainy days and air temperature. These factors will have some effect on fish population within the lake, but they will be used primarily to correct for angler success. Hot or rainy days and low water levels may cause anglers to report a lower success score that is not due to the quality of the sport fishery in a particular lake.

Once the scoring model for largemouth bass is complete, we will expand the FQI to other sport fish species. From the initial inspection of the data, FQI models can be prepared for bluegill, channel catfish and crappie (both black and white combined). Due to the limited number of lakes fitting the criteria and some sport fish species being limited to certain lakes, it may be more difficult to prepare an FQI for walleye/sauger, muskellunge, redear sunfish, smallmouth bass and others.

JOB 101.2 ENHANCED FIELD SAMPLING OF SPORT FISH POPULATIONS

OBJECTIVES

The following components constitute the overall objectives for Job 101.2:

- Conduct targeted and supplemental field sampling of sport fish populations to support the data needs of project activities

- Coordinate with other Federal Aid Projects and Division of Fisheries to fill gaps in sampling effort and create efficiencies among federally supported (DJ) projects

PROCEDURES

Project staff will coordinate directly with the Division of Fisheries to determine sport fish population sampling needs in an effort to meet the growing demand for field data collection to support research activities and the analytical needs of fisheries managers. Enhanced field sampling of sport fish populations also provides data needed for FQI development on selected wadeable and non-wadeable waters within the state. Project staff will be used to fill gaps in sampling needs that also support research objectives in this study and create flexibility in apportioning sport fish population sampling efforts to meet the needs of multiple Federal Aid Projects, in addition to the needs of the Division of Fisheries.

FINDINGS

Project personnel worked directly with IDNR Division of Fisheries to conduct sampling of stream fish assemblages in the Vermilion River (Wabash Drainage), Lower Cache River, Embarras River, Skillet Fork River and Wabash River basins of Illinois during the summer of 2011. A summary of data collected during those sampling trips is included below.

During the first half of 2012, project personnel coordinated stream sampling in the Hennepin Canal, Green River, Pecatonica River, and the Lower Kaskaskia River. Additional data collection, entry and analysis for 2012 collections is currently underway, and data collection during 2012 continues during Segment 26. Summary information regarding sport fish populations in these stream basins will be reported in the next segment report.

2011 Stream Sampling Summaries for data collected during 2011 are as follows:

Vermilion River Basin (Wabash Drainage)

Project personnel assisted with sampling on two main stem sites and 21 tributary sites on the Vermilion River Basin (Wabash Drainage). Electrofishing surveys produced up to 42 largemouth bass, 14 smallmouth bass, and 3 spotted bass per site. Largemouth bass were most abundant in

the North Fork Vermilion River in the tailwaters of the dam at Ellsworth Park in Danville. Smallmouth bass and spotted bass were most abundant in the North Fork Vermilion River west of Bismarck. The largest largemouth bass was 16 inches, collected from the Vermilion River upstream of the Danville Dam. The largest smallmouth bass was 17.5 inches and 2.2 pounds, collected from the Vermilion River north of Catlin. The largest spotted bass was 15.6 inches and 1.4 pounds, collected from the Saline Branch northwest of St. Joseph.

Lower Cache River Basin

A sport fish assessment was completed in 2011 on the Cache River south of Perks. Two stations on the main stem were sampled, where 1544 fish were collected consisting of 36 species. The most abundant species collected was gizzard shad, representing 26.3% of the sample, while sport fish collected included bluegill 25.78% (maximum TL = 7.5 inches), largemouth bass 6.15% (maximum TL = 18.5 inches), white crappie 2.2% (maximum TL = 7.9 inches), black crappie 1.55% (maximum TL = 10.2 inches), redear sunfish 0.78% (maximum TL = 10.2 inches), and channel catfish 0.45% (maximum TL = 29.1 inches).

One weekday and two weekend days each week, from May 29 through September 25, 2011, a creel survey was conducted at five access points in the Lower Cache River basin to assess the level of angling effort and angler catch rates in the watershed. Sampled sites included Docterman's Camp near Ullin, IL, the USFWS Lower Cache River Access Point near Pulaski, IL, River Bend Access Point near Benton, IL, the Sandusky Bridge in Sandusky, IL, and US Route 51 at Ullin, IL. Each site was surveyed for 90 minutes during each of 27 randomly selected sampling days (both weekdays and weekends). A creel clerk interviewed any anglers present during the designated survey time period, and data regarding angler effort, catch, and harvest were recorded.

Creel survey results showed that very few anglers were exploiting the Lower Cache River fishery during 2011. Through the course of 67.5 hours of survey time, anglers reported just over 52 hours of angling time, yielding only 34 caught fish. Species caught by anglers were freshwater drum, largemouth bass, white crappie, bluegill, spotted gar, bowfin, channel catfish, and grass pickerel. The limited amount of data available through this survey limits our ability to extrapolate usable estimates of annualized angling pressure, but given the survey design used in this study, it is reasonable to expect that actual fishing pressure is light on this system, but that a diverse array of sport fish are available to the fishing public.

Embarras River Basin

The Region III portion of the Embarras River Basin Survey included three main stem sites and 21 tributary sites. Electrofishing catch rates produced up to 13 largemouth bass and 6 spotted bass, averaging 6 largemouth bass and 4 spotted bass per hour at the main stem of the Embarras River sites. The tributary sites produced up to 13 largemouth bass and 1 spotted bass, averaging 2.7 largemouth bass and 0.1 spotted bass per site. Largemouth bass were most abundant in the Embarras River southeast of Tolono and Hurricane Creek north of Greenup. Spotted bass were most abundant in the Embarras River at Camargo and the tailwaters of Lake Charleston. The

largest largemouth bass was over 16 inches and 2.7 pounds, collected from the Embarras River at Camargo. The largest spotted bass was 14 inches and 1.7 pounds, collected from the East Branch Embarras River northwest of Villa Grove.

The Region V portion of the Embarras River Basin Survey consisted of three main stem sites and six tributary sites. Twenty-nine largemouth bass were collected, ranging up to 13.4" in size, and were most abundant in Brushy Creek, near Route 1 north of Lawrenceville. Spotted bass were most abundant in Brushy Creek where 21 individuals were collected, ranging up to 13" in size. Thirty-five channel catfish, ranging up to 23.6", were collected across multiple sites, with the highest abundances occurring in the Embarras River at Ste Marie, where they ranged up to 19.3" in size. Fourteen flathead catfish, ranging up to 31.9", were also collected across multiple sites.

Skillet Fork Basin

The Skillet Fork Basin Survey consisted of four main stem sites and four tributary sites. Thirty-four largemouth bass were collected, ranging up to 4.3" in size. Largemouth bass were most abundant in the Skillet Fork downstream of the Brush Creek confluence, NW of Wayne City. Twelve channel catfish were collected, ranging up to 17.7" in size. They were most abundant in the Skillet Fork, NW of Carmi.

Middle and Lower Wabash Tributaries

During basin surveys, project personnel assisted in the sampling of six tributary sites on the Middle Wabash River in Region III, and three tributary sites on the Lower Wabash River in Region V. On the Lower Wabash River tributaries, five largemouth bass were collected, ranging in size up to 2.8" in size. Four spotted bass were collected, ranging up to 9.4" in size.

Miscellaneous Stream Sampling

In addition to major basin survey sampling, project personnel participated in sampling efforts on the following surveys:

- Kickapoo Creek of the Sangamon River basin to assess a stream restoration project (12 sites)
- Unnamed tributary to Salt Creek of the Sangamon River basin to assess a stream restoration project (2 sites)
- Lone Tree Creek of the Sangamon River basin to assess recovery from a fish kill (2 sites)
- Fish Creek of the Sangamon River basin to assess the redspotted sunfish population (2 sites)
- Unnamed tributary to Beaver Creek of the Iroquois River basin to assess a population of state-listed species (2 sites)
- North Fork Vermilion River and 2 sites on the Vermilion River to assess the baseline fish population prior to proposed dam removal (2 sites)

RECOMMENDATIONS

The overall benefit of the collaboration between project personnel and IDNR Division of Fisheries to conduct sport fish assessments is exceptional. Data collected can and will be used to develop and test the FQI metric, provide summary information about sport fish opportunities to the public via www.ifishillinois.org, and support the research and management needs of multiple collaborators and peers. Coordinated stream surveys should continue in future segments and more detailed, long-term strategies for prioritizing sampling efforts throughout the state should be developed.

The Lower Cache River sport fishery is likely underexploited based on creel survey data collected in this study. Additional information from the angling public regarding perceived impediments to sport fishing on the Lower Cache River is needed to develop management objectives. A survey of anglers in the region is recommended to gather data on angler avidity, perceptions of the quality of the sport fishery and other factors that may be impediments to the angling public.

JOB 101.3 DETERMINE FACTORS AFFECTING FISHING QUALITY

OBJECTIVES

The following components constitute the overall objectives for Job 101.3:

- Evaluate long-term trends and spatio-temporal variation in the quality of sport fish populations
- Conduct experimental and manipulative experiments to identify the biological mechanisms affecting performance metrics in sport fisheries

Experiment 3.1 – Impacts of angling induced selection on aggression, nest guarding behavior, and reproductive success of male largemouth bass (*M. salmoides*)

Experiment 3.1 was completed in Segment 24.

Experiment 3.2 – Physiological mediators of nest abandonment decisions in largemouth bass during the spawning season

Experiment 3.2 was completed in Segment 24.

Experiment 3.3 – Impacts of reproductive success on smallmouth bass recruitment

Although often used to inform sport fish management decisions, the existence of a stock-recruitment relationship in black basses has yet to be demonstrated through rigorous testing. However, in species like the smallmouth bass that exhibit long-term parental care and are highly susceptible to angling while on the nest, recruitment may be directly related to the number of successful nests in a year. This long-term study has focused on the monitoring of the reproductive success of individual nesting smallmouth bass males within both river and lake habitats. A parallel experiment (Experiment 3.4) addresses the same question regarding largemouth bass.

PROCEDURES

Field experiments tested the association between nesting success, mating success and reproductive success in smallmouth bass, and if these correlated to recruitment of age 1+ individuals. For the past several spawning seasons, we have focused on a study site that provided both a healthy river population and two lake populations. All nesting males in each study site were surveyed by visual swims using a mask and snorkel. Data collected for each individual male bass that spawned included: date of spawn, location and depth of the nest, assessment of mating success (number of eggs laid), assessment of reproductive success (number of fry), size

of parental male, and duration of parental care for each male, as well as the occurrence of hook wounds from angling. Snorkelers swam transects to assess the number of age-1 and age-2 juvenile smallmouth bass to assess year class strength from the previous year.

FINDINGS

The long-term nature of this study has allowed us to document that there is a direct, positive relationship between the number of reproductively successful nests within a population of smallmouth bass and recruitment to age 1+ to the following season (Figure 2). In addition, a positive correlation existed between total number of nests and recruitment (Figure 3), as well as between the estimated number of fry produced and recruitment (Figure 4).

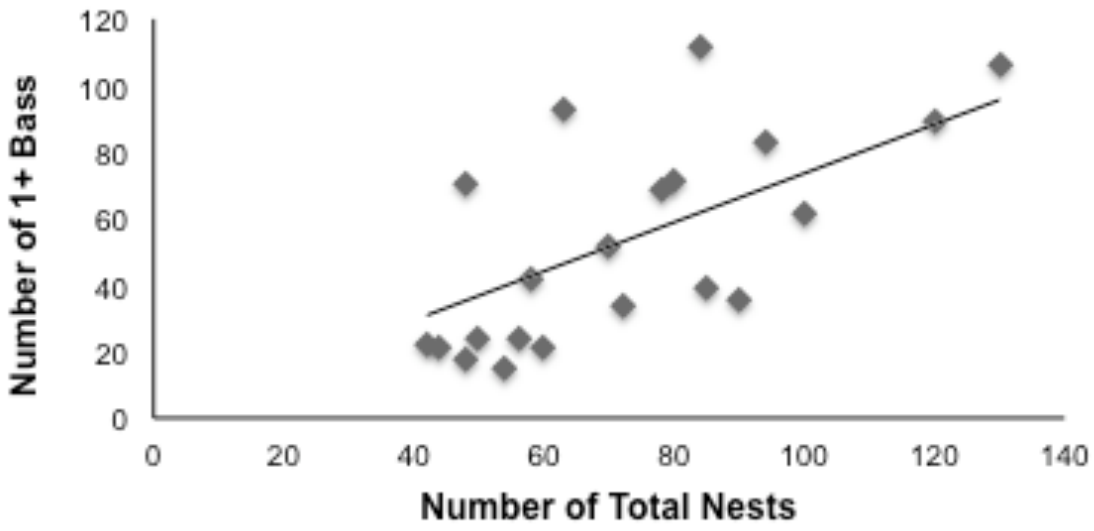

Figure 2. Relationship between those nests that successfully raised a brood to the total number of age 1+ bass observed in the following year.

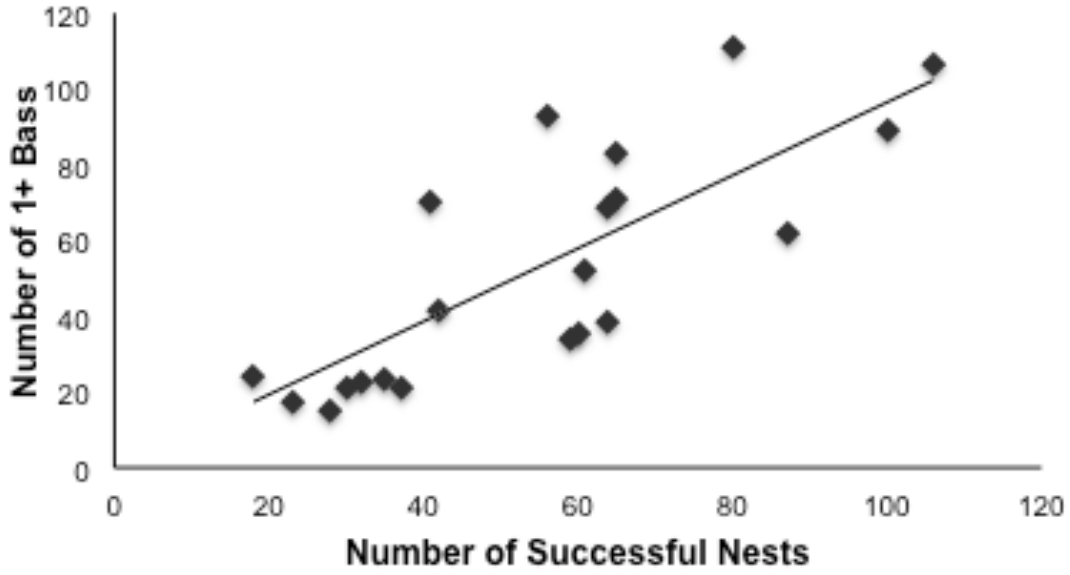

Figure 3. Relationship between the total number of nests where spawning occurred and the total number of age 1+ bass observed in the following year.

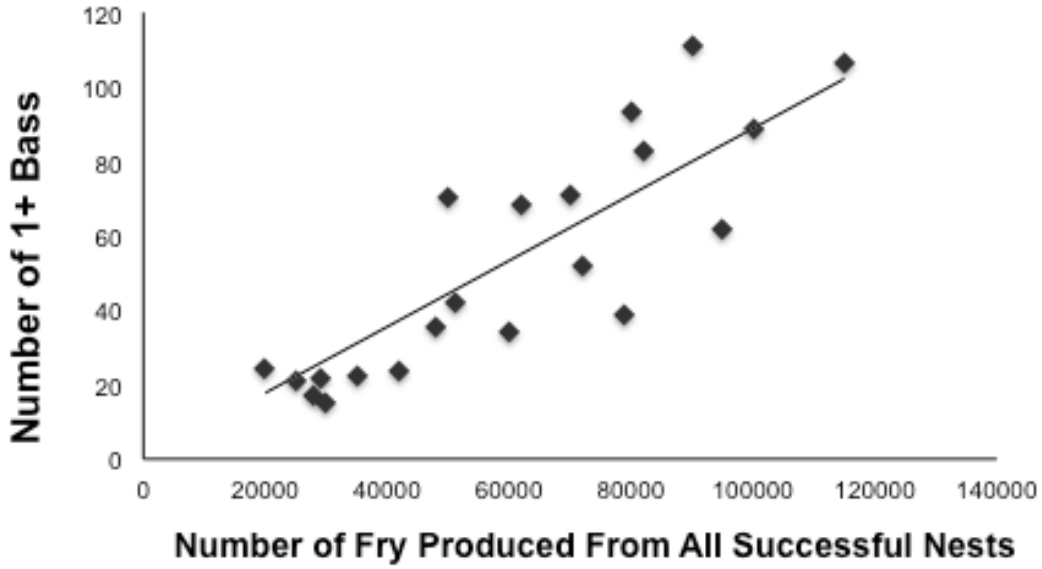

Figure 4. Relationship between the estimated number of fry produced and the total number of age 1+ bass observed in the following year.

RECOMMENDATIONS

Our results indicate smallmouth bass recruitment dynamics is directly related to reproductive success, and that this important link should be considered for successful management plans for this species. Management goals and strategies for smallmouth bass should include considerations for their parental care activities and the connection of reproductive success with year class strength, especially in systems where the management goal is improved recruitment. Analysis should continue on this long-term data set to better understand the effects of angling on nest-guarding males, recruitment mechanisms, yearly fluctuations in numbers of nesting and reproductively successful smallmouth bass, and if nest-site fidelity is a factor for management. This comprehensive project will continue to improve our ability to manage and conserve smallmouth bass populations in Illinois.

Experiment 3.4 – Impacts of reproductive success on largemouth bass recruitment

The uncertainty surrounding the existence of a stock-recruitment relationship in black basses requires investigation into alternative hypothesis to identify major drivers of black bass recruitment. Reproductive success may provide an important link to recruitment dynamics, especially for species that provide parental care and experience significant angling pressure during the reproductive season. In this long-term monitoring study, we tested the hypothesis that reproductive success in a given season is correlated with abundance of age 1+ recruits the following year by assessing yearly spawning activity and success, as well as following the recruitment of the age 1 cohort in largemouth bass. A parallel experiment (Experiment 3.3) was conducted focusing on smallmouth bass.

PROCEDURES

Total reproductive activity was measured by snorkelers locating all nests formed during each year's spawning season and quantifying the mating success for each male (numbers of eggs laid) and the success or failure of the brood (reaching the independent fry stage). These measurements were used to quantify annual lake-wide reproductive success (number of successful offspring produced) in whole largemouth bass populations. In addition, individual characteristics of each male (e.g., size, age, duration of parental care provided) coupled with the level of angling that occurred while male bass were nesting were used to assess the factors important for nest success or failure.

FINDINGS

Analyses of this long-term data set are currently underway to determine if lake-wide recruitment (i.e., annual year-class strength) is directly related to the reproductive success of the population. In addition, the long-term nature of this experiment will allow us to assess the long-term impacts of angling for nesting bass (from Experiment 3.1), and if those are associated with reproductive

success and/or recruitment of bass. Another benefit of this data set is that the impacts of environmental and climatic changes on largemouth reproduction can also be assessed.

RECOMMENDATIONS

The findings of this study will have important implications for understanding recruitment dynamics and management of largemouth bass populations in Illinois. Work should continue to better understand the reproductive dynamics of largemouth bass and how the removal of nest-guarding males may affect recruitment and state management plans for this species.

Experiment 3.5 – Assessing the impacts of invasive species on nesting bass

Drastic changes in the Great Lakes watershed have occurred in a very short period of time. The introductions of zebra mussels and round gobies have had significant effects on the environment, including water clarity, competition for food, and spawning habitat. Historical data collected prior to and during invasive species expansion can be a highly valuable tool when assessing the level of impacts these invaders have had on native populations of sport fish.

PROCEDURES

Biologists from SUNY College of Environmental Science and Forestry; the Fish Enhancement, Mitigation, and Research Project for the St. Lawrence Region; and the NY Department of Environmental Conservation, working at the Thousand Island Biological Station (TIBS), are currently assessing the impacts of zebra mussels and round gobies on fish populations in the St. Lawrence River just above Lake Ontario. Our lab conducted studies in this area 20 years prior when assessing the reproductive activity of smallmouth bass populations (see Experiment 3.3). During segment 25, project personnel met with TIBS researchers to compare data sets, as well as to discuss the possibility of repeating field studies to determine the impact zebra mussels and the round gobies may have had on smallmouth bass, rock bass and bluegill during their reproductive season. Researchers visited historical and novel study sites to assess the level of habitat quality and use by populations of nesting centrarchids. Visual assessments were completed using a mask and snorkel and swimming the shoreline to locate nesting sites. Preliminary evaluations of zebra mussel and round goby densities were also conducted.

FINDINGS

Preliminary field tests showed a significant change in habitat quality and use for nesting sites by smallmouth bass. However, until past methodology is repeated and exact study sites compared, these remain preliminary assessments.

RECOMMENDATIONS

We recommend that collaborative work with centrarchid biologists at the Thousand Island Biological Station be supported. One benefit of repeating past studies and comparing these data sets would be the insight into how invasive species are affecting reproductive activity within the Great Lakes in relation to distribution patterns of invasive species in Illinois.

Experiment 3.6 – Impact of brood loss on nest abandonment decisions by largemouth bass

Recruitment of sport fish is contingent upon various environmental and population pressures affecting larval and juvenile survival. However, for parental care-providing fish, such as largemouth bass, the rate of nest success among a population may be limiting to successful recruitment and subsequent year class strength. In particular, the occurrence of brood depredation by other fishes (e.g., bluegill, pumpkinseed), which may occur naturally or while a parental male is away from his nest following successful capture by an angler, is indicated to induce nest abandonment (i.e., nest failure) in largemouth bass, the consequence of which may negatively impact population-level recruitment. The objective of the current experiment was to determine, using a wild population of largemouth bass, the level of brood depredation required to induce nest abandonment by parental males.

PROCEDURES

Snorkel surveys were conducted from May through June 2011 in Lake Opinicon, Ontario, Canada to locate nesting largemouth bass. Largemouth bass nests were observed, and the number of offspring present (brood size, BS) was estimated using a commonly utilized scale from 1 (few offspring) to 5 (many offspring). To simulate brood depredation, a snorkeler situated above the nest removed 0, 25, 50, 75, or 100% of the eggs present using a plastic turkey baster, discarding the eggs away from the nest. A follow-up snorkel survey was conducted 24 hours following brood devaluation treatment; if the parental male was absent from the nest, the brood was considered abandoned, and nest failure was attributed to the devaluation treatment.

FINDINGS

Throughout the study, 123 largemouth bass nests were included for devaluation, of which 45 broods (37%) were abandoned by the 24-hour follow-up snorkel survey. Results indicate that experimental brood depredation did significantly induce premature nest abandonment by parental largemouth bass. Three separate indices were determined to predict brood abandonment, the most significant of which was the number of offspring remaining in the nest following experimental depredation (Figure 5). In particular, a threshold exists as remaining brood size approaches a value of 1, indicating that parental bass reassess the value of their brood following brood loss. Additionally, parental largemouth that experienced a greater change in brood size were more likely to forfeit their nest, and those with a greater brood size prior to devaluation were less likely to abandon their brood (Figure 6).

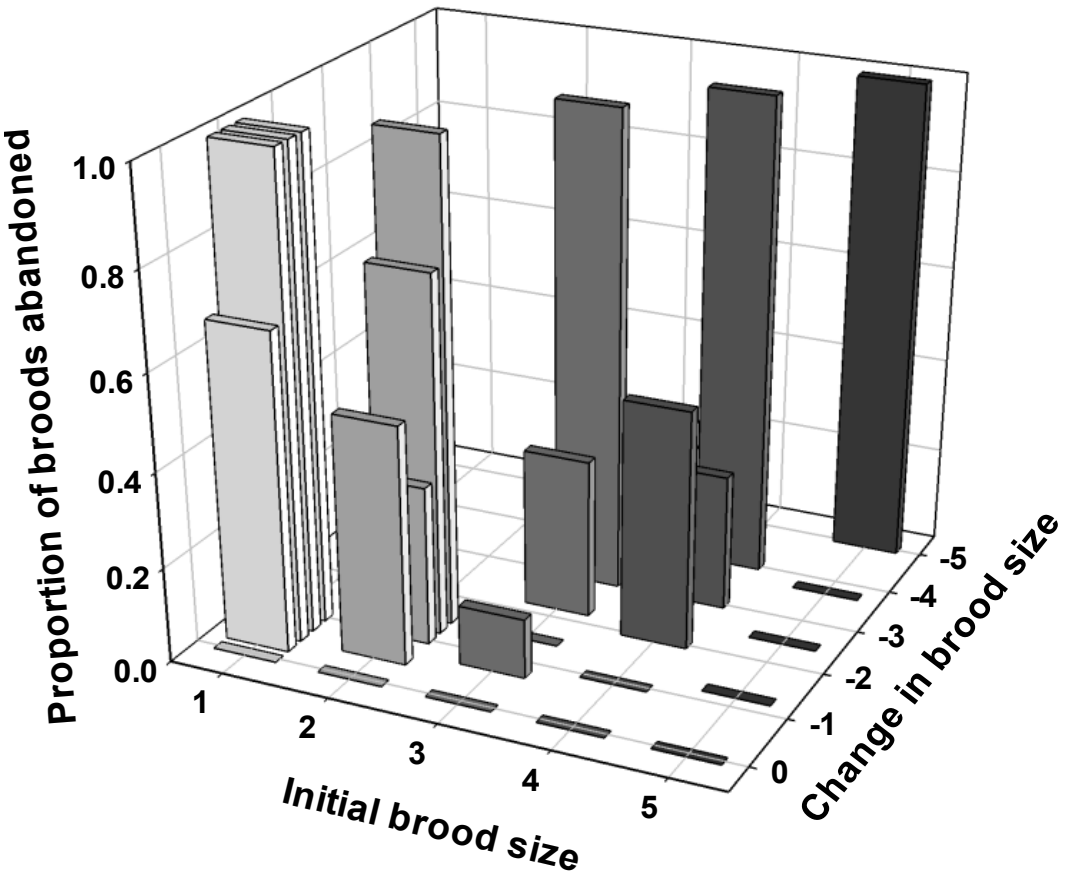

Figure 5. Proportion of parental largemouth bass that abandoned their nest following experimental brood devaluation. Shading represents initial brood size (BS, a categorical ranking of the number of offspring in a nest) prior to brood devaluation. Change in BS indicates the decrease in BS following experimental devaluation. Starting at a Change in BS of 0, bars within each Initial BS grouping indicate treatment levels of 0%, 25%, 50%, 75%, and 100% brood devaluation, respectively.

RECOMMENDATIONS

These findings indicate that brood loss does induce nest failure in largemouth bass, with potential consequences for population-level recruitment. Parental largemouth bass base nest abandonment decisions primarily on the number of offspring remaining in the nest, thus is it is highly advisable that the occurrence of brood depredation on a nest is minimized. It is advisable that future management actions consider brood depredation that may occur upon the removal of a parent largemouth bass from its nest, even in catch-and-release scenarios, as a viable driver of nest failure in the black basses. Further research into relationships between brood predator density and the rate of brood depredation are necessary to determine effective bass fishery management options.

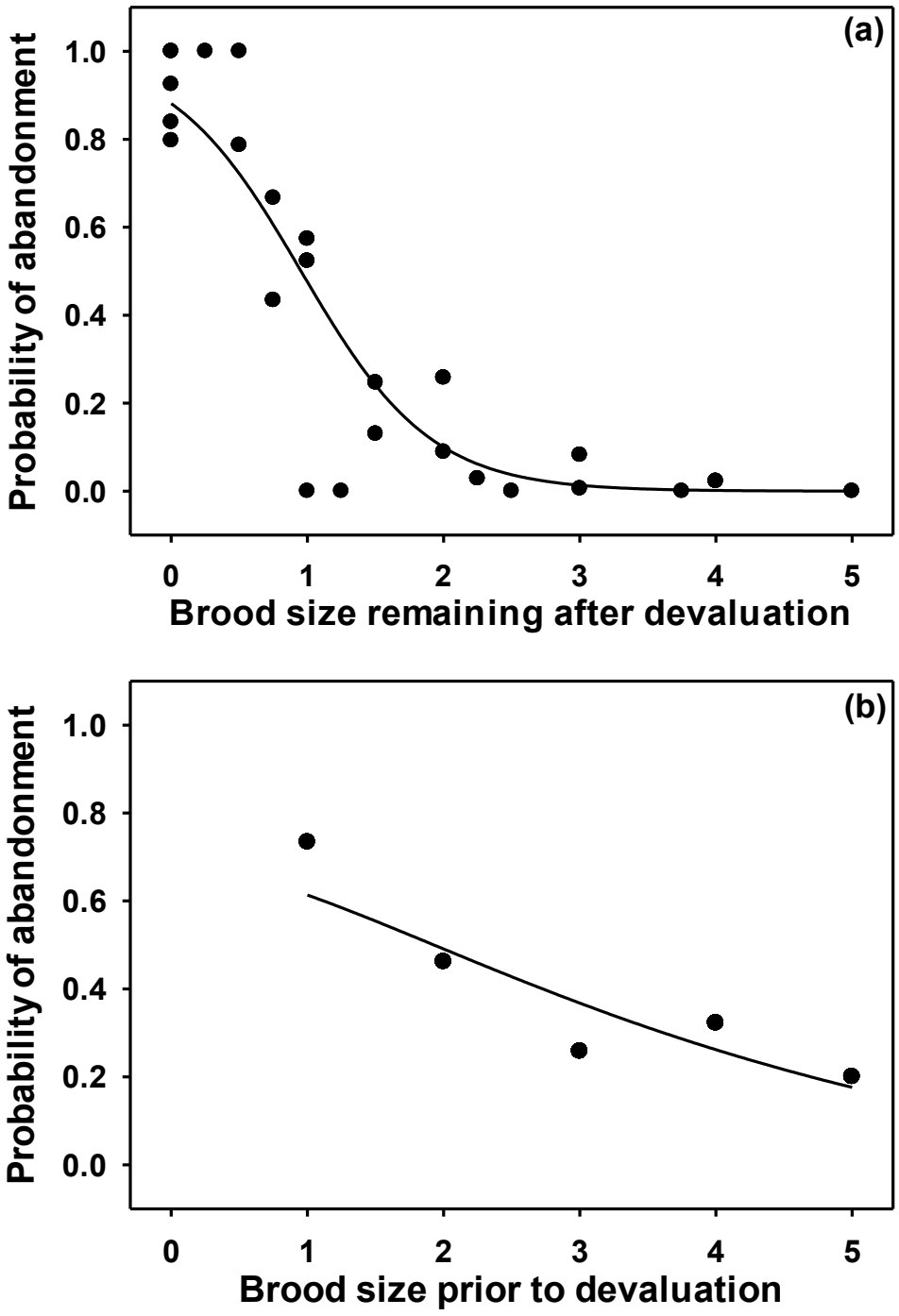

Figure 6. Probability of nest abandonment by largemouth bass relative to (a) brood size remaining after devaluation and (b) brood size prior to devaluation.

Experiment 3.7 – Parental care physiology in Centrarchids — insights from bluegill sunfish (*Lepomis macrochirus*) with implications for sport fish conservation

A broad number of economically important North American sport fish species provide parental care to significantly improve offspring survival, which contributed to the maintenance of viable fish stocks. The underlying hormonal and physiological changes associated to parental care, however, are complex, and how androgens, behavior-related enzymes, and peptide hormones such as prolactin and neuropeptides, interact with each other, change over the course of parental care, or can be affected by environmental conditions is not fully understood. The objective of Experiment 3.7 was to assess the role of various hormones in initiating and maintaining parental care behaviors in bluegill.

PROCEDURES

Territorial bluegill males of similar size were sampled throughout their reproductive period at three distinct stages: when establishing territories, guarding eggs, and guarding fry. Bluegill were collected in June 2011 using rod-and-line fishing and netting. During each of these stages, 10 males were sampled and tissue samples (brain, liver, muscle) were immediately preserved for laboratory analysis. A control group consisting of 10 males similar in size to the experimental fish were sampled prior to reproduction.

RNA from specific tissues was extracted from tissue samples in the laboratory and used to develop DNA primers, partial sequences of target genes and reference genes associated with the production of hormones related to parental care. DNA fragments from tissues samples were isolated and, based on the sequenced gene fragments, qPCR primers were created to quantify gene expression where the expression of target genes was compared to the expression of an internal standard.

FINDINGS

Preliminary results quantifying expression levels of the brain aromatase precursor gene reveal significant changes in expression levels. Low expression levels observed at the beginning of reproduction can be explained with high aggression of the nest-guarding males defending their nests. Higher expression levels that are observed at the end of the parental care period and for the control group can be related to lower aggression levels as fish do not defend territories at these times or are about to leave their independent brood. These expression patterns are in opposition to the previously described changes in testosterone expression of brood-guarding bluegill and largemouth bass, supporting the antagonistic role of this enzyme.

RECOMMENDATIONS

Findings of this study should be incorporated into future studies on largemouth bass to assess impacts of environmental characteristics and fisheries-induced evolution on reproduction,

behavior and physiology and to determine potential genetic causes for increased vulnerability to angling observed in certain largemouth bass. Determining factors operating during parental care behavior may clarify how brood development results in an adjustment in gene expression and translates to known changes in behavior of the parental male. Understanding how hormone expression varies as broods develop is essential to clarifying the consequences of reduced expression levels for reproduction and recruitment. Aquatic environments can be impacted by human land use through agricultural or wastewater effluents containing endocrine disruptors that may affect reproductive behavior. Understanding the suite of factors that may influence reproductive behavior, and ultimately recruitment dynamics, in sport fish is valuable in the context of sport fish management. As parental care is key for successful recruitment for a broad number of species, basic knowledge on how behavior-related genes are expressed during parental care is crucial for successful conservation management of these fish.

JOB 101.4 – COORDINATION WITH FISHERIES RESEARCH PROJECTS

OBJECTIVES

The following components constitute the overall objectives for Job 101.4:

- Provide supportive information on sport fish population dynamics/structure in study lakes, streams, and rivers associated with ongoing Federal Aid projects (e.g., F-101-R, F-135-R, F-138-R, F-123-R, F-52-R) and other federal- and state-supported activities (e.g., CAWFS-74, USFWS #301819G032)

- Maintain and enhance systems for managing and delivering fisheries data and analyses to data users

- Coordinate with related Federal Aid Projects and support the objectives of those projects where practicable

Several research experiments, ecological field studies, and collaborative activities were conducted in support of the objectives of Job 101.4. The procedures, findings, and recommendations for each of these activities are presented below.

Experiment 4.1 – Improved understanding of environmental tolerances of bass and bluegill

Experiment 4.1 was completed in Segment 24.

Experiment 4.2 – Development of molecular tools to quantify stress and disturbance in bass and bluegill

The stress response is common to all fishes and occurs following the perception of potentially harmful conditions. While the purpose of the stress response in fish is to maintain homeostasis and ensure survival, there can be negative consequences associated with prolonged upregulation of the stress response, including disease susceptibility, loss of performance, and reduced fitness. Typically, the stress response in fishes is quantified through the production of hormones, such as cortisol, which is sampled in blood. However, cortisol is expressed following a broad range of stressors and can be expressed following handling and/or sampling. Therefore, it would be advantageous to develop novel indicators of stress for fishes, particularly those that are robust against handling stressors or those that are expressed following specific stressors. Molecular markers, such as the expression of stress genes, represent sensitive stress indices that can be upregulated after specific environmental challenges and are quick to respond to challenges.

PROCEDURES

In FY2011, CAWFS-74, along with support from F-69-R project personnel, continued projects to develop novel molecular stress indices (i.e., development of stress biomarkers) using largemouth bass and bluegill. In particular, the project sought to define stress markers that could be quantified in red blood cells, allowing the non-lethal determination of stress for these sport fishes.

Using a closed system of circulating water, largemouth bass and bluegill were subjected to hypercarbia (high carbon dioxide). Red blood cells, heart, white muscle, and gill tissue were collected after a 1-hour exposure. Quantitative real-time PCR (qPCR) was utilized to determine the relative change of specific target genes in response to elevated carbon dioxide concentrations in the hopes of discovering genetic biomarkers for general and specific stressors. Briefly, RNA was extracted from the tissues excised from each fish and then created into DNA to be used as the template for qPCR. qPCR primers were created for several target stress genes, along with three possible reference genes. qPCR has been performed on silver carp and bluegill for red blood cells, gills, and heart tissues.

FINDINGS

Currently, primers have been developed for largemouth bass and bluegill (along with silver carp) for one gene expressed during hypercarbia stress (c-Fos), one gene expressed during hypoxia stress (HIF1-α), three general stress genes (GR-2, Hsc70-2 and Hsp70), along with three "housekeeping genes" (EF1-α, β-actin, and 18S) that can be used to normalize data generated using qPCR.

Through our work we have been able to show differential gene expression profiles between bluegill and silver carp that were exposed to hypercarbia. In red blood cells for both species, we did see increases in the mRNA production of key stress genes, though generally at a lower relative rate than similar increases in other tissues. Overall, we did not observe the upregulation of stress genes that respond to cell damage or protein unfolding (Hsp70 and Hsc70-2) after a 1-hour exposure to 30 mg/L dissolved CO_2. However, both species had tissue specific upregulation in stress genes that could activate a cascade of protective mechanisms to help the organism maintain homeostasis.

Work is nearly complete in quantifying the expression of these genes in the collected tissue for silver carp and bluegill. Once the data set has been completed, work will shift to producing a manuscript to publish in a peer-reviewed journal.

RECOMMENDATIONS

Results from this study represent a significant improvement in our ability to quantify stress and disturbance in sport fishes. The ability to non-lethally quantify molecular markers of stress in wild fishes will improve our ability to identify healthy vs. "stressed" populations of largemouth bass and bluegill, and this technology can then be applied elsewhere to other fish species. The

use of genetic stress markers can also be utilized in situations where blood collection is not possible, such as the determination of the molecular response of eggs, fry, and fingerling fish to carbon dioxide exposure. In addition, following publication in peer-reviewed journals, the primer sequences for the stress genes in largemouth bass and bluegill will be available for use by other researchers, allowing the expansion of these techniques elsewhere.

Experiment 4.3 – Development of novel chemical barriers to prevent the spread of Asian carp and to protect existing sport fish populations in the Great Lakes

Asian carp have the potential to harm valuable sport fisheries in the Great Lakes through habitat destruction and competition. Currently, there is a single electric barrier preventing the movement of Asian carp from the Mississippi River drainage to the Great Lakes basin. Electric barriers are size-selective, however, preferentially targeting large fish, and thus leaving smaller fishes free to escape the electric current. It is therefore valuable to develop additional, redundant barriers that are not size-selective to provide additional safety and security to the Great Lakes basin by deterring the movement of Asian carp.

PROCEDURES

In FY2011, CAWFS-74, along with support from F-69-R project personnel, completed projects whereby adult bighead carp (along with silver carp, largemouth bass, and bluegill, which were completed in FY2010) experienced conditions of elevated carbon dioxide in the laboratory. The primary goal of these experiments was to develop a chemical barrier to deter the movements of Asian carp into the Great Lakes Basin. Results, however, will not only improve our understanding of the physiological tolerance limits of sport fishes, but can also be used to adjust regulatory guidelines of environmental parameters that will benefit sport fish populations.

Individuals of each species were exposed to elevated dissolved CO_2 in a laboratory setting. During reflex response experiments, exposure to 30mg/L and 70 mg/L dissolved CO_2 were tested to determine the concentration and duration of exposure that caused fish to exhibit signs of discomfort and agitation. In later trials, fish were tested for indices of physiological stress after an exposure of 30 mg/L dissolved CO_2 for one hour. In an additional experiment, adult fish were placed into a choice arena where they had the ability to move from one chamber following exposure to dissolved CO_2. The concentrations of CO_2 when fish became agitated and then subsequently fled the treatment chamber were recorded and later analyzed.

In addition, experiments began late FY2011 to determine the effect of CO_2 on Asian carp eggs, fry, and fingerlings to test the feasibility of using a CO_2 barrier to deter small fish. Largemouth bass and bluegill of each age class were tested to determine the effect of CO_2 on species native to the Mississippi River and Great Lakes basin. Briefly, fish were exposed to physiological and avoidance trials similar to the above studies performed on adult fish, except dissolved CO_2 concentrations studied will be more aligned to the concentrations that induced reflex and avoidance behaviors in these fish.

FINDINGS

Through our work we have been able to elicit physiological indices of stress to CO_2, along with reflex and behavioral responses, in all fish examined. In addition, fish demonstrated active avoidance of elevated CO_2 at similar concentrations. This indicates that additions of dissolved CO_2 have the potential to act as a barrier to fish dispersal.

RECOMMENDATIONS

Further investigations and field trials are required before real-world implementation of CO_2 barriers can occur; the current results were generated from laboratory work under controlled conditions. The next steps would include large scale testing of CO_2 as a barrier to fish movement, along with continual experimentation investigating effects of CO_2 on different life stages of fish at concentrations similar to those seen during the "choice arena" portion of the current study. Work should be performed on cost feasibility, impacts on non-target organisms, and other potential environmental concerns to define limits of this potential solution.

Experiment 4.4 – Pulse-pressure as a deterrent to Asian carp movement

Asian carp have the potential to negatively impact valuable sport fisheries in the Great Lakes. Currently, the spread of Asian carp into the Great Lakes is largely imposed by a single electrical barrier in the Chicago Area Waterway. A non-physical barrier to invasive fish movement would provide support in protecting valuable habitat for lucrative sport fisheries, and would also continue to allow shipping through the Chicago Area Waterway. In this study the use of pulse-pressure technology to deter movement or drive movement of invasive silver and bighead carp was tested in an enclosed arena.

PROCEDURES

Individual bighead carp were collected by commercial harvesters and promptly tagged with acoustic telemetry tags. They were subsequently placed into a large net arena. Silver carp were also caught and placed in the arena but were not acoustically tagged. Two pulse-pressure devices were placed in the center of the arena prior to the addition of fish. After a control period where the fish were allowed to swim freely in the arena, the pulse-pressure devices were engaged for several hours. The movements of Asian carp in response to the pulse-pressure devices were quantified with acoustic telemetry, as well as hydroacoustic imaging. At the conclusion of firing, specimens were recollected and telemetry data was collected for later analysis. This procedure was run in duplicate for a total of two trials.

FINDINGS

Currently, results are being analyzed and will be reported in the annual report for Segment 26.

RECOMMENDATIONS

Awaiting results of the study; to be determined.

Experiment 4.5 – Lake Michigan Sport Fish Assessments

In June of 2010, project personnel began collaborations with the Illinois DNR Division of Fisheries to conduct research studies and management activities on Lake Michigan. Project personnel and DNR staff have begun identifying current and future research needs relative to Great Lakes sport fish restoration for consideration as specific activities in future segments.

PROCEDURES

Project personnel have continued collaborations with the Illinois DNR Division of Fisheries to conduct research studies and management activities on Lake Michigan. Project staff continues to assist with spring index netting, yellow perch assessments, data collection for a lake-wide predator survey, summer harbor electrofishing, yellow perch beach seine netting, fall salmonid electrofishing, and fall lake trout spawning assessments. As part of a multi-agency collaboration, personnel have also continued collecting data for a project aimed at calculating the ratio of wild Chinook salmon to stocked Chinook salmon by looking for the presence/absence of oxytetracycline marks in the vertebrate of Chinook salmon.

FINDINGS

In March of 2012, an estimated 300,000 Chinook salmon were marked at Jake Wolf Fish Hatchery (IDNR) as part of a lake-wide, inter-agency collaboration spearheaded by the U.S. Fish and Wildlife Service and also involving Michigan DNR, Indiana DNR, and Wisconsin DNR. In June of 2011, a new full-time position was added to the project staff to collaborate with Division of Fisheries and other agency partners on the mass marking project, as well as other fisheries management research studies on Lake Michigan.

RECOMMENDATIONS

F69R project personnel should continue coordinated data collection and analyses to support management activities and research studies. F-69-R project staff will meet with Illinois DNR Fisheries Lake Michigan Program staff and staff from other Federal Aid Projects, such as F-138-R (Lake Michigan near-shore fish communities), F-123-R (Yellow Perch), F-52-R (Lake Michigan Creel Survey), and USFWS Project #301819G032 (Evaluation of lake trout reef spawning areas), to determine knowledge gaps and research needs that can be addressed in the next segment of this Project.

Experiment 4.6 – Lake-Wide Coded Wire Tag Collection

In March of 2011, an estimated 300,000 Chinook salmon were marked at Jake Wolf Fish Hatchery (IDNR) as part of a lake-wide, inter-agency collaboration spearheaded by the U.S. Fish and Wildlife Service, and also involving Michigan DNR, Indiana DNR, and Wisconsin DNR. Project personnel have coordinated collection of tag recapture data from anglers who caught tagged Chinook salmon.

PROCEDURES

Automated tagging trailers were purchased by the U.S. Fish and Wildlife Service in 2010 to facilitate Chinook salmon and lake trout mass-marking. The goal of the mass-marking project is to eventually implant every stocked Chinook salmon and lake trout with a coded wire tag, which will yield information on natural recruitment and movements throughout the lake, including within and between fisheries jurisdictions. Personnel have assisted the IDNR with data collection efforts and also supervised a U.S. Fish and Wildlife Service technician who worked with personnel to collect data at other harbors in Illinois.

FINDINGS

Collection efforts began in May 2012 and will continue through the fall. Data collection for this project occurred simultaneously with another study and, to date, 483 specimens were sampled. Of those, 64 (13.3%) contained coded wire tags. Most (49%) Chinook salmon that entered the Lake Michigan fishery came from Wisconsin waters, with 31% coming from Michigan, 11% from Illinois, and 6% from Lake Huron; 3% of tags were lost. The number of Chinook salmon migrating from Lake Huron was an unexpected finding and is something all agencies will need to continue monitoring if reducing the predator burden on alewife (Chinook salmon's main forage fish) populations continues to be a management priority.

RECOMMENDATIONS

F-69-R project personnel should continue working with agency staff to assist the U.S. Fish and Wildlife Service with collecting data for this study. Personnel should attend the Lake Michigan Technical Committee Meetings to discuss findings and collaborate with other agency personnel to determine if additional research questions should be explored.

Experiment 4.7 – Modeling sport fish distributions in response to climate change

During Segment 25, project personnel initiated collaboration with the Landscape Conservation Cooperative project "Predicting Climate Change Effects on Riverine Aquatic Insects Using Museum Data and Niche Modeling." Throughout this collaboration, project scientists will build upon models used to predict distributions of aquatic insects to develop predictions of distribution of both game and non-game fishes in Illinois rivers and streams in response to various climate

change scenarios. Understanding potential long-term changes in sport fish communities and the forage base on which they depend will assist resource managers in developing long term strategies to cope with climate-related changes in flows, temperatures and other abiotic characteristics in rivers and streams.

PROCEDURES

We used species occurrence records for more than 100 stonefly species (*Insecta*: *Plecoptera*), distributed across the five-state Upper Midwestern study region (OH, IL, IN, MI, WI), to build species distribution models to summarize patterns of richness and diversity at a series of spatial scales. These models are built from over 100 soils, geology, general landforms, temperature, precipitation and pre-European settlement land cover variables. We model the distribution of these species at three different spatial grains: 1 km^2 and 0.1° raster cells (modeled from gridded climate data) and by HUC12 watershed, (a set of hierarchically arranged, irregular polygons of watersheds).

FINDINGS

All suites of models predict similar patterns of species richness. Most notably, there are "hotspots" of higher maximum species richness along much of the southern margin of the study area, just north of the Ohio River, but also in the northeastern portions of Wisconsin and the Upper Peninsula of Michigan (Figure 7). Models built from 1 km^2 scale climate grids predict a very similar pattern (Figure 8) as the larger suite of environmental variables summarized by polygon. In our models, the tilled plains and corn belts of IN, IL and MI have lower species richness of stoneflies than other regions of the study area.

Whatever the explanations, these natural breaks in the distribution of species might provide insights into fisheries management. Spatial variation in the diversity of the regional species pool has implications to total biomass, trophic structure, and many other types of ecological interactions that can influence dynamics of managed populations. The viability of strategies (e.g., harvest season date, slot limits) designed to manage stable clines in behavior or physiological interactions (e.g., brooding behavior, timing of cues for nest building, etc.) may be disrupted by climate change on ambient water temperatures or changes in timing and magnitude of high and low flow events in lotic systems.

Patterns of reduced species richness in these areas is likely to reflect (at least, in theory) changes in the suitability associated with the massive habitat loss, alteration and degradation resulting from intensifying agricultural production, but may be influenced by serial overlap of the ranges of individual species associated with biogeographic breaks. Indeed, many stonefly species in our data set are associated with Appalachian, Laurentian or Great Plains distributions, but we have not modeled the entire range of species that occur outside of our data set.

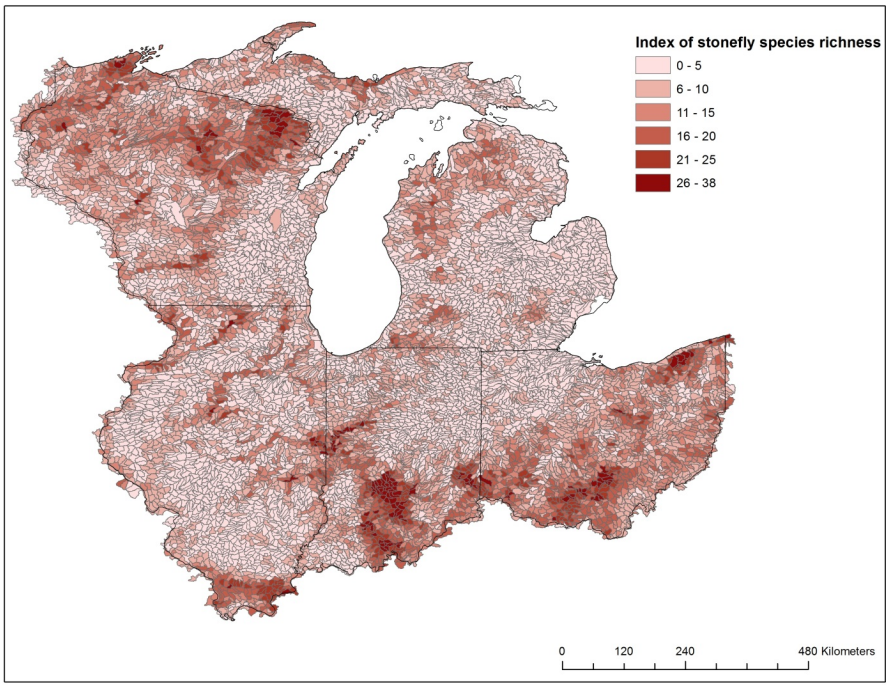

Figure 7. Patterns of species richness in watersheds across the upper Midwest, predicted from models built from soils, geology, temperature, precipitation and historical land cover irregular polygons.

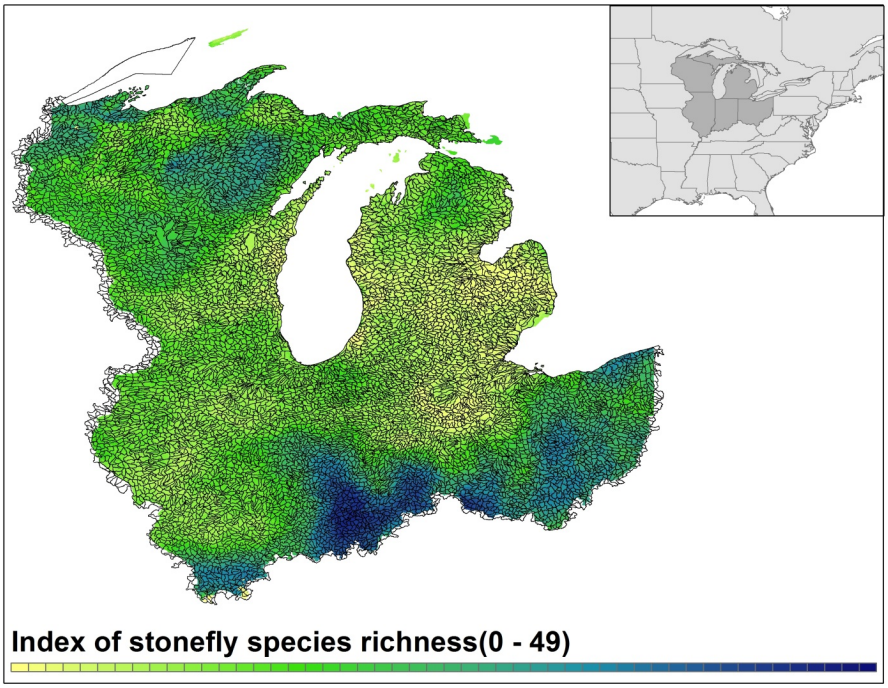

Figure 8. Patterns of species richness in watersheds across the upper Midwest, predicted from models built from gridded 1 km^2 raster cells of temperature and precipitation data alone.

RECOMMENDATIONS

Future work will provide assessments of the change in climates predicted by regionally downscaled models for the five-state Upper Midwest region. We will use these predictions to model watershed flow regimes to predict changes in the availability and quality of fish habitat for fishes. If analyzed in light of the necessary data on life history traits or demographic bottlenecks, predictive climate models could also be useful to managers who seek to predict changes in the suitability of habitats for introduced species.

Sport Fish Data Set Organization and Access

Access to fisheries data sets and the efficient and coordinated management of those data sets are critical to the successful completion of all aspects of Project F-69-R. As project staff seek to utilize existing fisheries information and ensure that future data collection meets the needs of this and other federal- and state- supported fisheries research, continued access to sport fish data sets are required.

Project personnel have continued collaborations with IDNR Division of Fisheries to identify necessary modifications and improvements to the collection, storage and retrieval of fisheries information by researchers, managers, and the public. Project personnel are developing online data browsing tools for use by project personnel to support activities in Job 101.1, Job 101.2, Job 101.3, Job 101.5, and Job 101.6.

FINDINGS

Data browsing tool development has focused on making significant improvements and alterations to handling data generating from IDNR hatchery activities. Utilizing .NET application frameworks, an online tool that prioritizes requests for sport fish stockings, monitors hatchery production, and records the destination of hatchery-reared fished has been developed and is ready for testing by hatchery personnel. This “Stocking” node will be fully integrated into future nodes of fisheries data (i.e., sport fish population assessments in lakes, streams, large rivers) so that project researchers will have rapid and simple access to sport fish information about IL water bodies that includes management actions such as stocking events as well as natural variations in sport fish abundance and distribution.

Sport fish data sets utilized by project personnel come from a variety of relatively isolated sources (e.g., creel surveys, lakes surveys, streams surveys), and the many sampling sites within those data sets continue to lack adequate geospatial referencing to support Project F-69-R objectives. Project personnel have begun developing options for modifying how sport fish information is managed to efficiently integrate multiple data sources, include sufficient geospatial data, and broaden the scope of use of the information to support research and management activities.

RECOMMENDATIONS

Efficiently integrating sport fish data sets is a difficult endeavor that requires the continued attention of F-69-R project personnel and a strong collaborative partnership with IDNR Division of Fisheries. Development of the Stocking node should be completed during Segment 26, and additional nodes will begin to be developed thereafter. Additionally, project personnel will explore collaborations with IDNR units, as well as other state agencies, to assemble geospatial referencing information about sample sites that is currently missing from sport fish data sets. Geospatial data along with information about sport fish populations can then be integrated more efficiently into information delivery systems to the sport fishing public, primarily through activities incorporated into Job 101.5. Further efficiencies and modifications to fisheries information systems should be explored and implemented in future project segments, thus making information about sport fish populations in Illinois more readily accessible to researchers, managers, and the public.

JOB 101.5 – SUPPORT AND ENHANCE WEB INTERFACE

OBJECTIVE

The following components constitute the overall objectives for Job 101.5:

- Enhance and maintain a web interface for the dissemination of sport fisheries data and analyses to the public, and develop additional site enhancements upon request of DNR Fisheries.

PROCEDURES

Project personnel continue to maintain and enhance the website www.ifishillinois.org as the primary method for providing online information about sport fishing opportunities to the public. The website provides information about Illinois sport fish, including weekly fishing reports, findings on long-term analyses of sport fisheries data, trends in fishing quality, and the promotion of Illinois as a fishing destination. This effort makes sport fisheries-related information readily available to the public and continues to provide immeasurable benefit to current and prospective anglers in Illinois.

The website www.ifishillinois.org provided an excellent framework to house guidelines and information for anglers on conservation angling, as it is already a highly popular site with Illinois anglers. Content was produced and the new "Conservation Angling" section was developed for www.ifishillinois.org. The first step was to develop introductory materials that encompassed all types of angling, including: Introduction to Conservation Angling, Code of Angling Ethics, Conservation Practices for Anglers, Catch-and-Release Guidelines, and Science of Recreational Angling, which highlights the research conducted in Illinois and/or funded by Sport Fish Restoration Funds. Specific topics included: appropriate gear (e.g., barbless hooks and circle hooks), air exposure, depth of capture, hooking location, bleeding, landing, recovery time, revival techniques, properly weighing a fish, photographing with least impact, and angling during the spawning season. The first stage of the new "Conservation Angling" section was completed and went live in April 2012.

FINDINGS

Conservation Angling on www.ifishillinois.org

Evaluation of the Conservation Angling section on www.ifishillinois.org was conducted using Google Analytics to follow the visit and revisit patterns by various users (3,179 page views on the catch-and-release guidelines page from April – June, 2012). In addition, an online survey was posted and provided a method for visitors' feedback, asking for comments and requests. This feedback has allowed us to address specific angler needs for information and make adjustments for future webpages.

Outreach Materials for Fishing Shows

In coordination with IDNR Division of Fisheries, project personnel developed backdrop materials for the fishing trade show booths to enhance their presentation. Project personnel also developed full-color, one-page fact sheets on approximately 40 Illinois lakes that included analyses of recent fisheries data and overviews of the quality of sport fishing on each lake. Visitors to the IDNR booth were encouraged to take home fact sheets and a small card that included the web address for www.ifishillinois.org for easy reference.

Social Media

The growing popularity of www.ifishillinois.org and the dominance of social media as a method to create online communities motivated project personnel to create an I Fish Illinois Facebook page. Initiated in April 2011, the I Fish Illinois Facebook page announces all the timely information regarding sport fishing in Illinois, including promotion of IDNR-sponsored events, IDNR press releases pertaining to sport fish and Illinois lakes, tournament announcements, fishing license reminders, and news items that may be of interest to Illinois anglers. As of this report date, we have 174 "likes." In addition to the posts, we get a significant number of messages and questions that come through Facebook, which project personnel always answer within 24 hours of the post.

Improvements and Additions to www.ifishillinois.org

Lake Profile Pages: Throughout the site, lake profile pages were updated with the most current fishing prospects, based on the expertise and recent data collected by IDNR fisheries biologists.

DuPage River: In support of new research efforts under Job 101.4, project personnel added materials informing the angling public about the research and monitoring efforts developing on the West Branch of the DuPage River. A two-minute informational video was created and placed on the website, providing anglers and the general public background information about the collaboration between the University of Illinois, the Forest Preserve District of DuPage County, and the IDNR Division of Fisheries. Anglers were provided instructions on how to report tag numbers from any stocked smallmouth bass they captured while angling.

Alabama Rig: With the growing popularity of the Alabama Rig among largemouth bass anglers, background information about the rig and how Illinois regulations apply to the use of the rig was added. Materials were developed in coordination with IDNR Division of Fisheries, and as new regulations come into effect, the website will be updated accordingly.

General Website Improvements: Project personnel provided updated and easier-to-read information regarding sport fishing prospects for over 40 lakes across Illinois and made significant changes to numerous highly visited pages to improve overall readability and accessibility of information. Overall, information about visitors to www.ifishillinois.org indicates that the website's popularity continues to grow as coordination between project personnel and IDNR Division of Fisheries provides additional material for the website, promoting sport fishing opportunities in Illinois waters.

Website Statistics Analysis

This project segment represents the first full annual cycle with Google Analytics in place to collect information regarding visitors to www.ifishillinois.org. Google Analytics provides reports on how often each page is visited, which pages have the highest numbers of visitors, the trends in the website visitors (e.g., higher on weekends, holidays, etc.), which pages have the highest exit rates, etc. (Figure 9). This information allows us to assess where we need to focus our time and efforts to improve the site and to ensure that we are providing the public information in which they are interested.

Visitor Information

- From July 1, 2011 – June 30, 2012, we had 248,319 visitors to the www.ifishillinois.org site, with a total of 1,455,518 page views.
- On our most visited day, 1524 visitors viewed our site in a 24-hour period.
- Each visitor views an average of 6 pages per visit.
- Of all visitors, 63% find us using a search engine, while 27% find us through the DNR website and 10% come directly to our site by typing in the web address.

Content Information

- The Weekly Fishing Report page is the most-visited page.
- Our regional lake selection page is the second most-visited page.
- Of the regional lakes, Region 2 is the most visited, followed by Region 1, then Region 4, Region 3, and Region 5.
- Region 2 had three times as many visitors as Region 5.
- The most popular lake profile is Lake Michigan, followed in order by the Fox Chain O' Lakes, Heidecke, Busse, Tampier, Shabbona, and Shelbyville Lakes.
- The Kids Hotspot page continues to be in the top 10 most-visited pages on our site, which lead to a significant improvement of layout for that page in this FY.
- If there is a link that directs a visitor away from our site (e.g., DNR link) or directs you to a download, we cannot track these as they are not included in Analytics.

RECOMMENDATIONS

Overall, the new Conservation Angling section has proved to be a popular area among visitors to www.ifishillinois.org. This follows the nationwide trend seen by other state and federal agencies as the angling community becomes more aware about the importance of catch-and-release angling. To address angler requests, as well as further develop existing topics, future work will include species-specific guidelines, the science of catch-and-release, and best handling practice recommendations for fishing tournaments. In addition, we will be using the www.ifishillinois.org example to lead discussions on providing consistent and science-based Conservation Angling information to anglers at both the upcoming Black Bass Symposium (February 2013) and at the 2013 Annual American Fisheries Society Meeting.

In addition to the Facebook page, project personnel will implement a Twitter feed that will be used to provide timely sport fish information to the public. This will include information from IDNR news releases; angling opportunities, including tournament information and IDNR-sponsored events; site closures; etc. In addition, project personnel will use the Twitter feed to report sport fish related items of interest "live" from any sport fish-related conferences they may be attending. The Twitter feed will be featured on the homepage of the www.ifishillinois.org website to promote sport fishing in Illinois.

Information about visitors to www.ifishillinois.org indicates that the website's popularity continues to grow as coordination between project personnel and IDNR Division of Fisheries continues to provide additional information about sport fishing in Illinois waters. Further integration of fisheries information from data sources including coordination conducted under Job 101.4 of Project F-69-R will provide science-based information for anglers and managers alike. As the development of the Fishing Quality Index proceeds in future segments under Job 101.1, its inclusion in web pages profiling individual lakes as well as statewide status reports will further enhance the quality and quantity of information provided to the angling public.

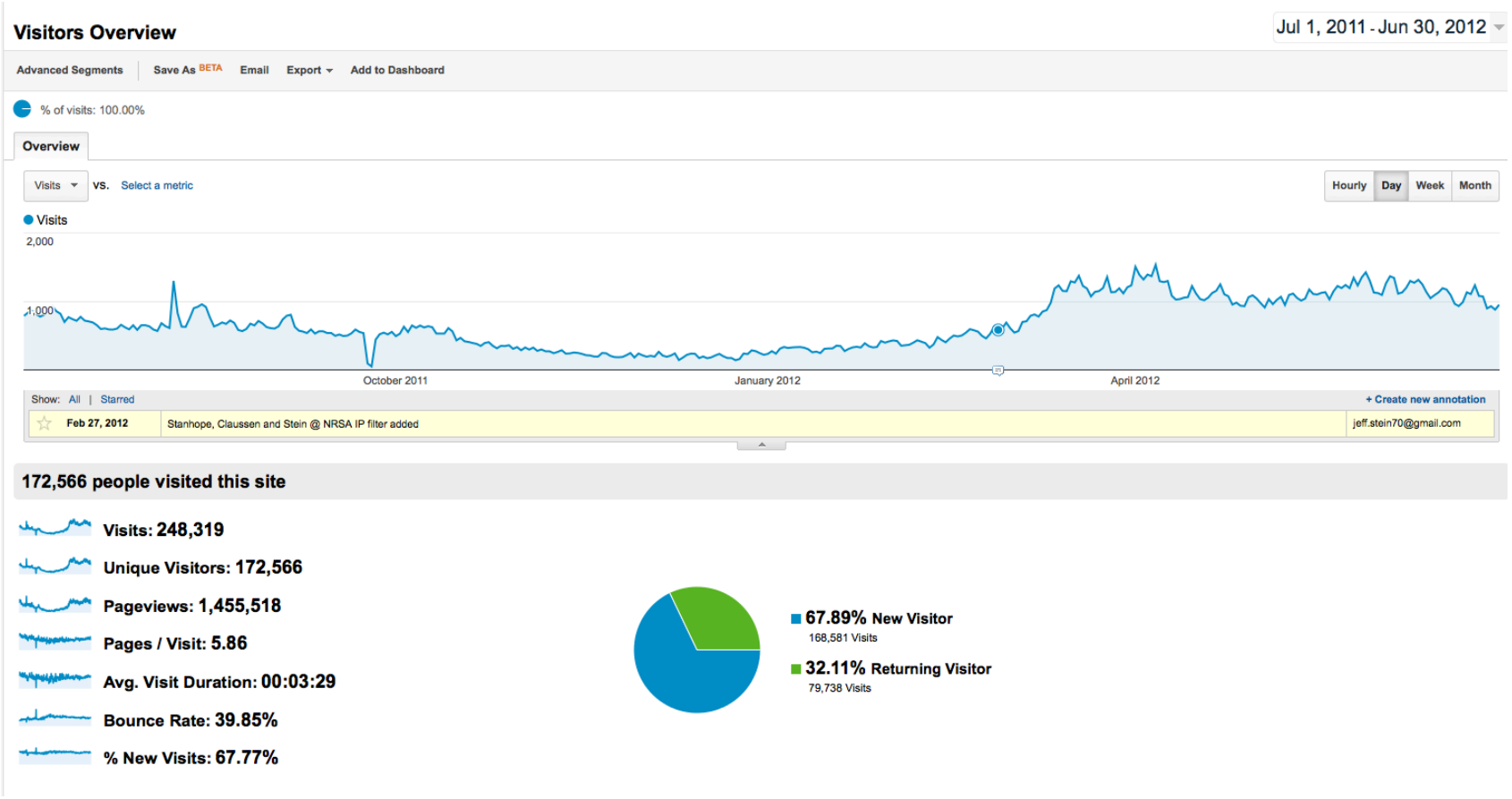

Figure 9. Overview of the number of daily visits to www.ifishillinois.org during Segment 25 (July 1, 2011 — June 30, 2012). Note: The dip in traffic on a day in October was due to our server being down for the day.

JOB 101.6 – FISHES OF CHAMPAIGN COUNTY

OBJECTIVE

The following components constitute the overall objectives for Job 101.6:

- Analyze the changes in fish species in Champaign County during the past 100 years and identify components of stream fish assemblages that have significantly changed over time, as well as the key factors contributing to those changes over the last century.

PROCEDURES

Building on the efforts of Forbes and Richardson (1908), Thompson and Hunt (1930), Larimore and Smith (1963), and Larimore and Bayley (1996), the next iteration of "The Fishes of Champaign County" (FoCC) began in the 2012 field season. The study includes the sampling of fish populations at pre-determined field sites, assembly and analysis of land use and stream habitat data, collection and analysis of physio-chemical habitat data, and analysis of the effect of fish community and environmental parameter interactions on distribution and assemblage characteristics. To the maximum extent practicable, field crews are replicating the sampling methods (e.g., electric seine and block nets) and locations (140+ sample sites) used in previous iterations of this long-term study (previously funded under Federal Research Project F-76-R).

In addition to the field sampling efforts, a mail survey was created and sent to the landowners with sampling locations on or adjacent to their property. This questionnaire was created to assess the attitudes of the landowners toward the streams on their land, as well as how they utilize their stream. Questions asked if the landowners were anglers and if they fished their stream, whether or not they participate in Conservation Reserve Programs, if they have heard of the Illinois Recreational Access Program, and what their opinion was of the wildlife in their stream.

FINDINGS

One hundred and fifty sample locations were identified from previous FoCC surveys. These sites were geospatially referenced and entered into ArcMap software. Using an electronic plat map of Champaign County and a sample site map, landowners were identified for the mail survey. Addresses were obtained and the survey was first mailed on March 30, 2012, followed by a second mailing on May 1, 2012. In addition, during this time period, sampling gear (electric seine, dip nets, water quality monitors and other assorted gear) were purchased and assembled, as well as field technicians for the sampling crew hired.

Sampling began May 15, 2012, and by the end of this segment, 38 sites have been sampled. The sites in the Embarras River drainage basin were the first to be sampled, followed by sites on the Kaskaskia River Basin. By June 30th, nearly all sites in both basins had been sampled. Sampling

efforts on the Embarras River yielded 42 fish species. In comparison, Larimore and Bayley's last FoCC survey collected 41 species, and the Department of Natural Resources' stream sampling in 2006 on the Embarras River in Champaign County (only 1 site) collected 20 species. 42 species were also collected in the Kaskaskia River Basin during this summer's sampling. Larimore and Bayley collected only 38 species from this basin, and IDNR Stream Sampling from 2002–2007 collected 37 species.

We mailed 221 landowner surveys, and we received back 105 useable surveys, resulting in a 52% return. For most sites, multiple landowners (2–4) were identified and sent surveys, so receiving half of the surveys likely means we received a good sampling of all sample sites. Preliminary results show that only 22% of responding landowners are recreational anglers and the majority of them fish public lakes and private ponds. Thirty six of 98 of the responders (37%) allow fishing on their Champaign County stream. We also asked about the landowner's participation and knowledge of certain government programs and found that 51% participate in CRP/CREP, while only 12% have heard of the Illinois Recreational Access Program (IRAP).

RECOMMENDATIONS

Field sampling should continue through the remainder of 2012 in the Saline Branch, Middle Fork and Little Vermilion River Basin. The Sangamon River and Salt Fork River basins should be sampled in 2013, and should be coordinated with IDNR basin sampling in the Sangamon. In addition, some sites sampled this summer should be revisited next summer in accordance with previous FoCC methods. Many of the sites sampled in this project are located in the headwaters of four rivers (Embarras, Kaskaskia, Little Vermilion and Salt Fork of the Vermilion). Additionally, the Little Vermilion and Middle Fork of the Vermilion have a relatively small area within Champaign County. In order to make better comparisons of these rivers to other sampled rivers, project personnel should add sample sites in the Ford County portions of the Middle Fork and in the Vermilion County portions of the Little Vermilion River.

Once fish sampling is complete, project personnel should analyze changes over time in the fish assemblages of prairie streams in east central Illinois and evaluate factors impacting stream fish populations. Additionally, data collected through the landowner's survey should be used to analyze perceptions of stream fish populations relative to actual assessments. Project personnel should provide landowners with an in-depth analysis of streams in their area as a way to promote awareness and stewardship of local sport fish resources. Poor name recognition for the Illinois Recreational Access Program highlights the need for additional efforts to promote the program to the general public. Illinois DNR should consider marketing strategies that utilize traditional and internet-based methods for promoting the IRAP program.

Segment 25 Job Costs - Budget v. Actual

	Budget	Actual	Over/(Under)
Job 101.1 – Sport Fish Population and Sport Fishing Metric	$77,941	$77,492	($449)
Job 101.2 – Enhanced Field Sampling of Sport Fish Populations	$216,894	$212,402	($4,492)
Job 101.3 – Determine Factors Affecting Fishing Quality	$445,551	$441,541	($4,010)
Job 101.4 – Coordination with Ongoing Fisheries Research Projects	$75,916	$68,430	($7,486)
Job 101.5 – Support and Enhance Web Interface	$87,694	$86,157	($1,537)
Job 101.6 – Fishes of Champaign County	$89,143	$86,498	($2,645)
Total Costs	**$993,139**	**$972,520**	**($20,619)**
Federal Share	**$744,854**	**$729,365**	**($15,489)**
State Share	**$248,285**	**$243,155**	**($5,130)**

Literature Cited

Cooke, S. J., C. D. Suski, K. G. Ostrand, D. H. Wahl and D. P. Philipp (2007). "Physiological and behavioral consequences of long-term artificial selection for vulnerability to recreational angling in a teleost fish." Physiological and Biochemical Zoology **80**(5): 480-490.

Forbes, S. A. and R. E. Richardson (1908). The Fishes of Illinois. Urbana, IL, Illinois State Laboratory of Natural History**:** 357.

Larimore, R. W. and P. B. Bayley (1996). "The Fishes of Champaign County, Illinois, During a Century of Alternations of a Prairie Ecosystem." Illinois Natural History Survey Bulletin **35**(2): 53-183.

Larimore, R. W. and P. W. Smith (1963). "The Fishes of Champaign County, Illinois, as Affected by 60 Years of Stream Changes." Illinois Natural History Survey Bulletin **28**(2): 299-382.

Philipp, D. P., S. J. Cooke, J. E. Claussen, J. B. Koppelman, C. D. Suski and D. P. Burkett (2009). "Selection for Vulnerability to Angling in Largemouth Bass." Transactions of the American Fisheries Society **138**(1): 189-199.

Redpath, T. D., S. J. Cooke, C. D. Suski, R. Arlinghaus, P. Couture, D. H. Wahl and D. P. Philipp (2010). "The metabolic and biochemical basis of vulnerability to recreational angling after three generations of angling-induced selection in a teleost fish." Canadian Journal of Fisheries and Aquatic Sciences **67**(12): 1983-1992.

Thompson, D. H. and F. D. Hunt (1930). "The fishes of Champaign County: a study of the distribution and abundance of fishes in small streams." Illinois Natural History Survey Bulletin **19**(1): 1-101.